

WHAT IS CLAIMED IS:

1 1. A method for making a heating element adhered to a substrate,
2 the method comprising:

3 applying a photocurable composition to a substrate in a pattern having
4 one or more grid lines, the photocurable composition curable into an electrically
5 conductive layer and having volatile organic compounds present in an amount of
6 less than about 10% of the total weight of the photocurable composition; and

7 illuminating the photocurable composition to light for a sufficient
8 period of time to cure the photocurable composition that has been applied to the
9 substrate.

1 2. The method of claim 1 wherein volatile organic compounds
2 are present in an amount of less than about 5% of the total weight of the
3 photocurable composition.

1 3. The method of claim 1 wherein volatile organic compounds
2 are present in an amount of less than about 1% of the total weight of the
3 photocurable composition.

1 4. The method of claim 1 wherein the substrate comprise a
2 component that is at least partially soluble in volatile organic compounds or is
3 softened by volatile organic compounds.

1 5. The method of claim 1 wherein the pattern further includes
2 one or more busbar from which the one or more gridlines extend.

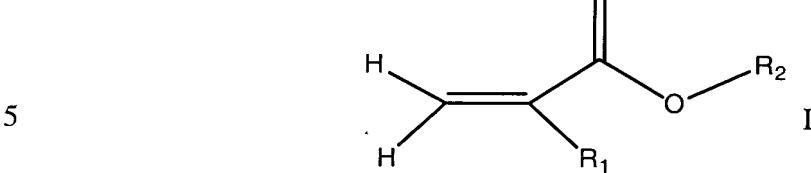
1 6. The method of claim 1 wherein the pattern comprises a first
2 busbar and a second busbar wherein the one or more gridlines extend between and
3 are in electrical contact with the first busbar and the second busbar.

1 7. The method of claim 1 wherein the photocurable composition
2 comprises:

3 a photocurable organic mixture;
4 an electrically conductive composition; and
5 a photoinitiator.

1 8. The method of claim 7 wherein the photocurable organic
2 mixture comprises:

3 one or more photocurable oligomers; and
4 an ethylenically unsaturated monomer having Formula I:



6 wherein R₁ is hydrogen or substituted or unsubstituted alkyl; and
7 R₂ is substituted or unsubstituted alkyl having more than 4 carbon atoms, cycloalkyl,
8 cycloalkenyl, or substituted or unsubstituted aryl.

1 9. The method of claim 8 wherein R₁ is hydrogen or methyl, and
2 R₂ is isobornyl, phenyl, benzyl, dicylcopentenyl, diclypentenyl oxyethyl,
3 cyclohexyl, and naphthyl.

1 10. The method of claim 8 wherein the ethylenically unsaturated
2 monomer is an isobornyl acrylate monomer.

1 11. The method of claim 8 wherein the one or more photocurable
2 oligomers are selected from the group consisting of an aliphatic acrylated
3 oligomers, an acrylated epoxy oligomers, and mixtures thereof.

1 12. The method of claim 7 wherein the photocurable composition
2 comprises an aliphatic acrylated urethane oligomer and an acrylated epoxy
3 oligomers.

1 13. The method of claim 7 wherein the electrically conductive
2 composition comprises a component selected from the group consisting of silver,
3 carbon black, a doped metal oxide, and mixtures thereof.

1 14. The method of claim 7 wherein the electrically conductive
2 composition comprises silver powder and silver flakes in an amount of at least 20%
3 relative to the weight of the silver powder.

1 15. The method in claim 7 wherein;
2 a) the photocurable organic mixture comprises:
3 an aliphatic acrylated urethane oligomer is present in an amount of
4 about 3% to 8% of the total weight of the photocurable composition;
5 acrylated epoxy oligomer is present in an amount of about 2% to 4%
6 of the total weight of the photocurable composition; and
7 an isobornyl acrylate monomer is present in an amount of about 4%
8 to 8% of the total weight of the photocurable composition; and
9 b) the electrically conductive composition comprises:
10 silver powder is present in an amount of about 50% to 60% of the
11 total weight of the photocurable composition; and
12 silver flakes are present in an amount of about 25% to 35% of the
13 total weight of the photocurable composition.

1 16. The method of claim 15 wherein the photocurable composition
2 further comprises a flow promoting agent.

1 17. The method of claim 15 wherein the electrical composition
2 further includes a second conductive powder selected from the group consisting of
3 carbon black and a doped metal oxide.

1 18. The method of claim 15 wherein the substrate is a flexible
2 substrate.

1 19. A method for making a heating element adhered to a substrate,
2 the method comprising:

3 a) applying a photocurable composition to substrate in a pattern
4 having one or more grid lines, the photocurable composition comprising
5 an aliphatic acrylated urethane oligomer;
6 acrylated epoxy oligomer;
7 an isobornyl acrylate monomer;
8 silver powder;
9 silver flakes; and
10 a photoinitiator, wherein the photocurable composition has less than
11 about 10 weight % volatile organic compounds; and
12 b) illuminating the photocurable composition to light for a
13 sufficient period of time to cure the photocurable composition that has been applied
14 to the substrate.

1 20. The method of claim 19 wherein the silver flakes are present
2 in an amount of at least 20% relative to the weight of the silver powder.

1 21. The method of claim 19 wherein,
2 the aliphatic acrylated urethane oligomer is present in an amount of
3 about 3% to 8% of the total weight of the photocurable composition;
4 the acrylated epoxy oligomer is present in an amount of about 2% to
5 4% of the total weight of the photocurable composition; and
6 the isobornyl acrylate monomer is present in an amount of about 4%
7 to 8% of the total weight of the photocurable composition;

8 the silver powder is present in an amount of about 50% to 60% of the
9 total weight of the photocurable composition; and

10 the silver flakes are present in an amount of about 25% to 35% of the
11 total weight of the photocurable composition.

1 23. The method of claim 19 wherein the pattern further includes
2 one or more busbars from which the one or more gridlines extend.

1 24. The method of claim 19 wherein the pattern comprises a first
2 busbar and a second busbar wherein the one or more gridlines extend between and
3 are in electrical contact with the first busbar and the second busbar.

1 25. The method of claim 19 wherein the substrate is a flexible
2 substrate.

1 26. A heating element adhered to a flexible substrate made by the
2 method comprising:

3 applying a photocurable composition to a flexible substrate in a
4 pattern having one or more grid lines, the photocurable composition curable into an
5 electrically conductive layer and having volatile organic compounds are present in
6 an amount of less than about 10% of the total weight of the photocurable
7 composition; and

8 illuminating the photocurable composition to light for a sufficient
9 period of time to cure the photocurable composition that has been applied to the
10 flexible substrate.

1 27. The heating element of claim 26 wherein the pattern further
2 includes one or more busbars from which the one or more gridlines extend.

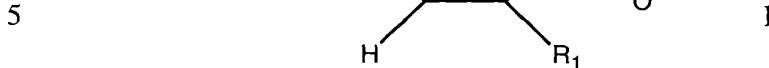
1 28. The heating element of claim 26 wherein the pattern comprises
2 a first busbar and a second busbar wherein the one or more gridlines extend between
3 and are in electrical contact with the first busbar and the second busbar.

1 29. The heating element of claim 26 wherein the photocurable
2 composition comprises:

3 a photocurable organic mixture;
4 an electrically conductive composition; and
5 a photoinitiator.

1 30. The heating element of claim 29 wherein the photocurable
2 organic mixture comprises:

3 one or more photocurable oligomers; and
4 an ethylenically unsaturated monomer having Formula I:



5 6 wherein R₁ is hydrogen or substituted or unsubstituted alkyl; and
7 R₂ is substituted or unsubstituted alkyl having more than 4 carbon atoms, cycloalkyl,
8 cycloalkenyl, or substituted or unsubstituted aryl.

1 31. The heating element of claim 30 wherein R₁ is hydrogen or
2 methyl; and R₂ is isobornyl, phenyl, benzyl, dicylcopentenyl, diclypentalenyl
3 oxyethyl, cyclohexyl, and naphthyl.

1 32. The heating element of claim 30 wherein the ethylenically
2 unsaturated monomer is an isobornyl acrylate monomer.

1 33. The heating element of claim 30 wherein the one or more
2 photocurable oligomers are selected from the group consisting of an aliphatic
3 acrylated urethane oligomers, an acrylated epoxy oligomers, and mixtures thereof.

1 34. The heating element of claim 29 wherein the photocurable
2 composition comprises an aliphatic acrylated urethane oligomer and an acrylated
3 epoxy oligomers.

1 35. The heating element of claim 29 wherein the electrically
2 conductive composition comprises a component selected from the group consisting
3 of silver, carbon black, a doped metal oxide, and mixtures thereof.

1 36. The heating element of claim 29 wherein the electrically
2 conductive composition comprises silver powder and silver flakes in an amount of
3 at least 20% relative to the weight of the silver powder.